preliminary tremors in seconds. In the present case the calculated distance is 4445 kilometers (2762 miles), a result which, without corroborative data, must be regarded as very problematic.

The reasoning in this case is to this effect: Earthquakes in general are caused, it is believed, by more or less sudden breaks or slips or fractures in the crust of the earth. Yielding of a gradual sort may have been going on for a long time before, but when the final fracture comes the phenomenon we call an earthquake results, and elastic and quasi-elastic waves of both compression and distortion and of a highly complex character radiate from the origin in all directions. The purely elastic vibrations within the elastic limits of the strata, and hence of smaller amplitude, are undoubtedly transmitted at a higher linear velocity than the great surges which doubtless strain the earth materials far beyond the elastic limit and are soon dissipated. Hence, we should expect the earthquake record to begin with preliminary tremors and this is found to be the case, except in very rare instances. The absence of preliminary tremors in the case of the present earthquake as recorded at Victoria would indicate a nearby origin for the disturbance.

A study of the records of distant earthquakes shows a most marked difference in the velocity of propagation of different phases of the phenomena. From Omori's investigations, already referred to, the *preliminary* tremors are transmitted at an average velocity of 12.8 kilometers per second; whereas, the large waves of the principal portion of the earthquake travel at the slow rate of only 3.3 kilometers per second. The theory of the speed of propagation of vibrations would require that the elastic properties of the strata should exceed those of steel in order to give the observed high velocities of the preliminary tremors.

A satisfactory explanation of this apparent conflict with our knowledge of the elastic properties of bodies has not yet been offered. A theory has been advanced that the preliminary tremors make a short cut for the distant station by traveling through the earth rather than around it, but even in this case the transmitting medium must have a very high modulus of elasticity.

THE DISTRICTS OF THE DOMINION OF CANADA.

In answer to many inquiries the Editor submits the accompanying sketch map, kindly furnished by Prof. R. F. Stupart, showing the names and locations of recent subdivisions in the Northwest Provinces of Canada.

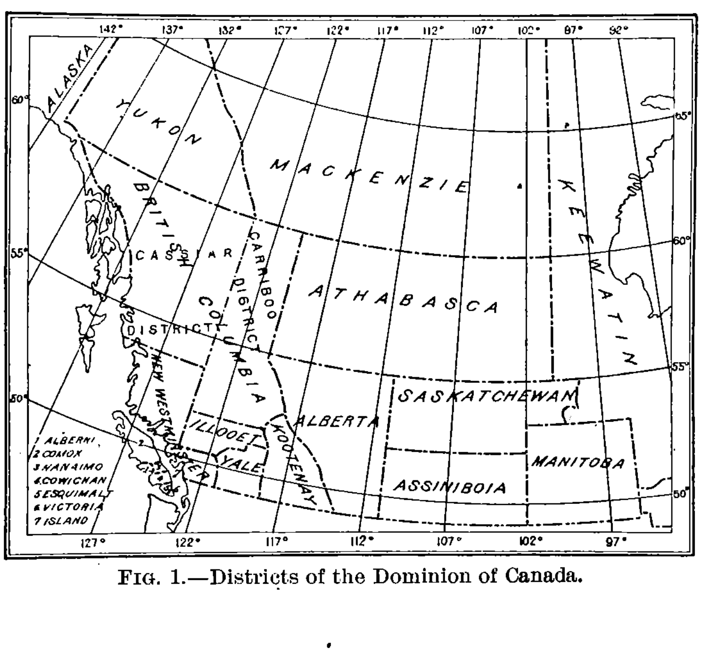

FIG. 1.—Districts of the Dominion of Canada.

THE SEMIDIURNAL TIDES IN THE NORTHERN PART OF THE INDIAN OCEAN.

By R. A. HARRIS, of the United States Coast and Geodetic Survey.

In this paper an attempt will be made to show by means of cotidal lines the average Greenwich lunar time of high water over the northern part of the Indian Ocean. Of course an unlimited number of sets of cotidal lines can be drawn which shall satisfy all reliable observations because the measurements of the tide have been confined to shores and islands. But unless one duly considers the causes and nature of the tide it is almost certain that such arbitrary lines will, when carried out far from land, represent an impossible state of affairs.

Before passing to the subject proper, it may be well here to call attention to the desirability of procuring more and better observations on many of the islands. Observations should also be made over shoals and, if possible, at places of greater depths.

It is the intention of the writer to cover the sea and all its principal arms with cotidal lines similar to those here shown in fig. 5. The maps showing such lines will probably also appear in an appendix to the United States Coast and Geodetic Survey Report for the year 1904. In view of this considerable delay, it is reasonable to suppose that the map accompanying this paper may by that time be modified somewhat in ways suggested by future observations and experience.

In fig. 5 Roman numerals denote the Greenwich lunar time of mean high water; when decreased by the east longitude of the place expressed in time they give its establishment in lunar hours. The Arabic numerals, generally scattered along the shores, denote the approximate mean range of tide in feet. Values given to tenths of a foot are based upon harmonic analyses; bracketed values indicate the range of the semidiurnal part of the tide where the latter is chiefly diurnal.

The northern part of the Indian Ocean is chosen for study at this time because the origin of the tide is there more easily accounted for than in most other regions, and because the results of extensive observations made by the survey of India, by the Dutch, and by the British Admiralty are available.[1]

In Appendix No. 7, United States Coast and Geodetic Survey Report for 1900, an attempt is made to partially explain the principal ocean tides. A preliminary sketch of parts of the theory involved in this appendix may be found in the MONTHLY WEATHER REVIEW for March, 1900, and this sketch should be consulted if the full paper is not available.

The Indian Ocean north of the thirtieth degree of south latitude is, with one exception, but little influenced by the tides of other waters. The exception is due to the fact that there is a good rise and fall around southern Africa, and in Mozambique Channel, where the tide depends upon two systems of oscillations which are determined by boundaries largely outside of the region to be considered in this paper. These systems, styled south Atlantic and south Indian, are described in Chapter VII of the Appendix No. 7 above referred to. It may be noted here that observations indicate about I.5 as the Greenwich lunar time of high water in Mozambique Channel, and that this is about the theoretical time of the tide, for it is a mean between XII or 0 and III; see fig. 1, which is taken from the chart of semidiurnal systems in the paper just referred to. Extending from Mozambique Channel to Baluchistan and India is a half-wave area whose time of tide, as will be noted later, is largely governed by the tide in the channel.

[1] Most of the data used in the construction of the accompanying map may be found in the British Admiralty Tide Tables; The United States Coast and Geodetic Survey Tide Tables; and Appendix No. 7, United States Coast and Geodetic Survey Report for 1900, sections 79–97 and figs. 25, 29.